MATRIX INVESTIGATION OF PRIMITIVE METEORITE MIL 07687: 2D-3D COMPARISON.

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Introduction: Unaltered carbonaceous chondrites (CC) are remnants from the disk stage of Solar System evolution and they contain fine grained matrix that preserves primitive dust. The matrix is a mixture of fine-grained materials, composed largely of amorphous silicate, sub-micrometre forsterite and enstatite grains and micrometre sized aggregates of such crystals [1]. The ungrouped carbonaceous chondrite MIL 07687 is an Antarctic meteorite which has been previously classified as a CO3 chondrite, but shows unique properties that make this meteorite different from typical CO chondrites [2]. This meteorite appears to be a rare example of a chondrite showing evidence of partial alteration of fine grained matrix, providing important insights on the diversity of processes that occurred in the early Solar System [2].

Experimental methods: Ultra high-resolution image and element maps of MIL 07687 matrix regions were acquired using Carl Zeiss Ultra Plus and FEI Quanta 650 FEG SEM respectively [3, 4]. Micro-XRD analyses were directly collected from the selected areas on the thin section using a Rigaku D max Rapid II. A pin-hole of 30 µm was used to achieve an X-ray beam footprint on the sample of ~50 x 500 µm. SEM and micro-XRD investigations were carried out at the Natural History Museum in London.

TEM work was performed at Kyoto University on FIB-ed foils, during which element map were acquired on selected areas within the TEM foil, using a JEM-2100F (JEOL LTD, Japan) operated at acceleration voltage of 200kV.

Investigations of the matrix carried out on the thin section in 2D were complemented with a three-dimensional imaging study. Cubic-shaped matrix samples of approximately 30×30×30 µm in size were extracted with FIB technique at Kyoto University using Helios FEG-SEM/FIB (FEI Helios NanoLab Dual Beam).CT imaging of selected matrix regions were acquired at SPring8 synchrotron facility in Japan using a Frenel zone plate BL-47XU X-ray synchrotron radiation in order to obtaining 3D internal structures [5, 6]. Imaging tomography experiments were carried out at 7keV and 8keV with resolution: >~35.9 nm and >~41.1 nm respectively.

Result and discussion: Image and element maps acquired have highlighted the presence of different matrix regions characterised by different degrees of aqueous alteration due to the partial alteration of fine grained matrix exhibited by the meteorite. In the micro-XRD patterns of the matrix we identify the following crystalline phases: forsterite, enstatite, iron sulphide and metal. All regions investigate with micro-XRD are characterised by diffraction patterns with shapes similar to our poorly crystalline ferrihydrite standard.

The average abundance volumes for MIL 07687 obtained using a profile-stripping method are: olivine 18vol%, enstatite 18vol%, 1vol% Fe-sulphide, metal is only present in one area that is weakly altered. The remaining 63% contribution, of which no strong peaks are present is likely to be attributed to the poorly crystalline phases e.g. ferrihydrite and/or amorphous silicates. In that respect the chemical composition of the amorphous material observed in the TEM map was produced in lab, and micro-XRD are being collected in order to estimate the abundance of amorphous phase which is being carried out.

The three-dimensional imaging investigation of the matrix has revealed differences in the matrix porosity distribution compared to the 2D observations acquired on thin section surface. Variation in the type of matrix lithologies, not necessary visible in the 2D investigations, were also observed. The differences in these matrix regions, and how these differences may be evidence of parent body processes (e.g. aqueous alteration) and/or protoplanetary disk processes will be discussed.

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